Solar Modeling for Systems Driven Approach

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MYTP Systems Driven Approach Activities

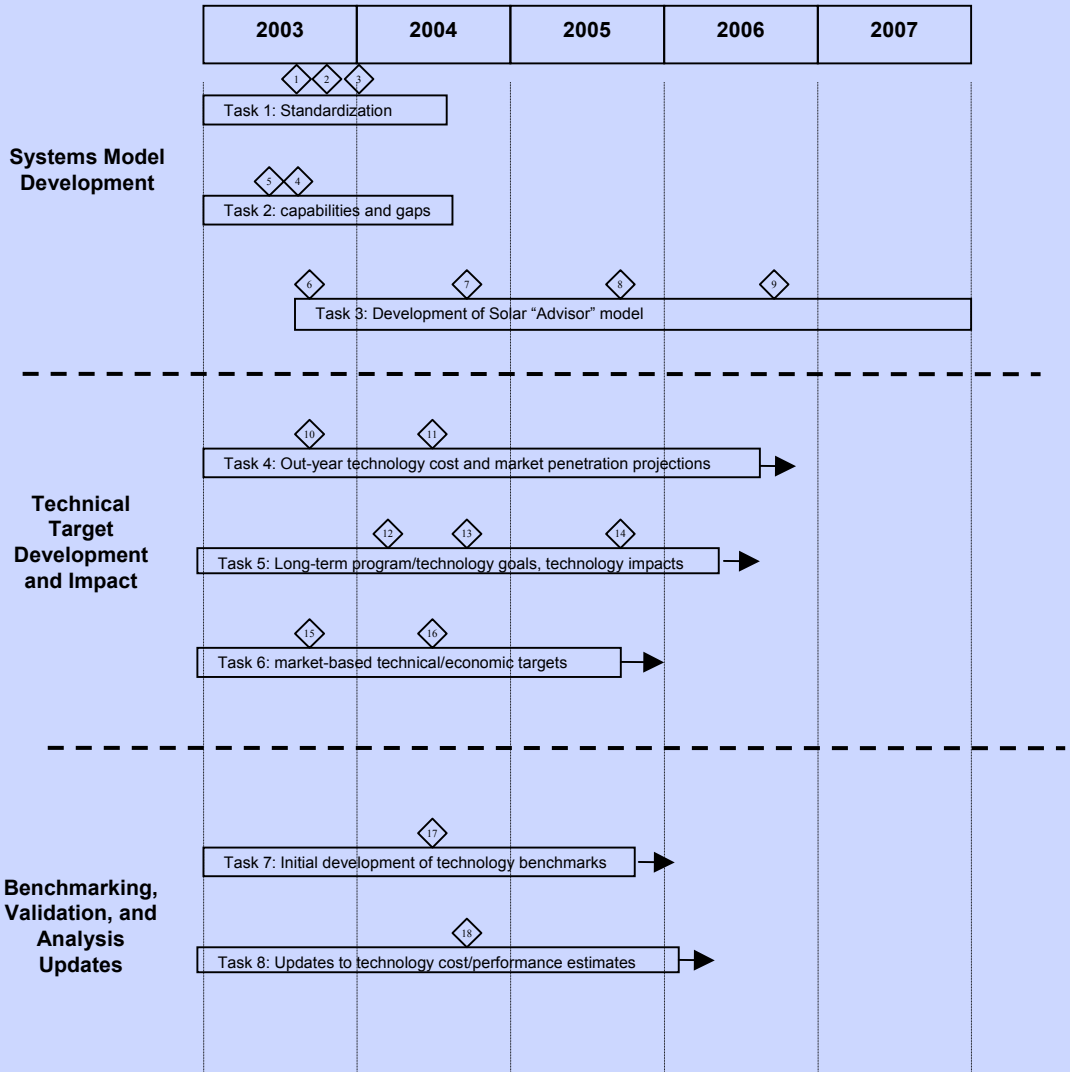
- Develop Solar Systems Model
- Develop Market-Based Technical Targets and Impact Estimates
- Conduct Technology Benchmark, Validation, and Analysis Updates

Systems Modeling Development Approach

- Development of Stand-Alone PV Advisor Model
  - Quickly build PV model w/o need to wait for more complex integrated model
  - Support development of PV model w/ emphasis on standard cost and financial methodologies.
  - Integrate validated PV model components into solar advisor model

- Development of Integrated Solar Advisor Model
  - Performance/financial analysis of distributed, central station, and buildings-integrated solar technologies
  - Solar technologies will include PV, CSP, and SH systems
  - Beta model for at least one market (multiple technologies) will be developed in FY04

Modeling Project Plan (MYTP)

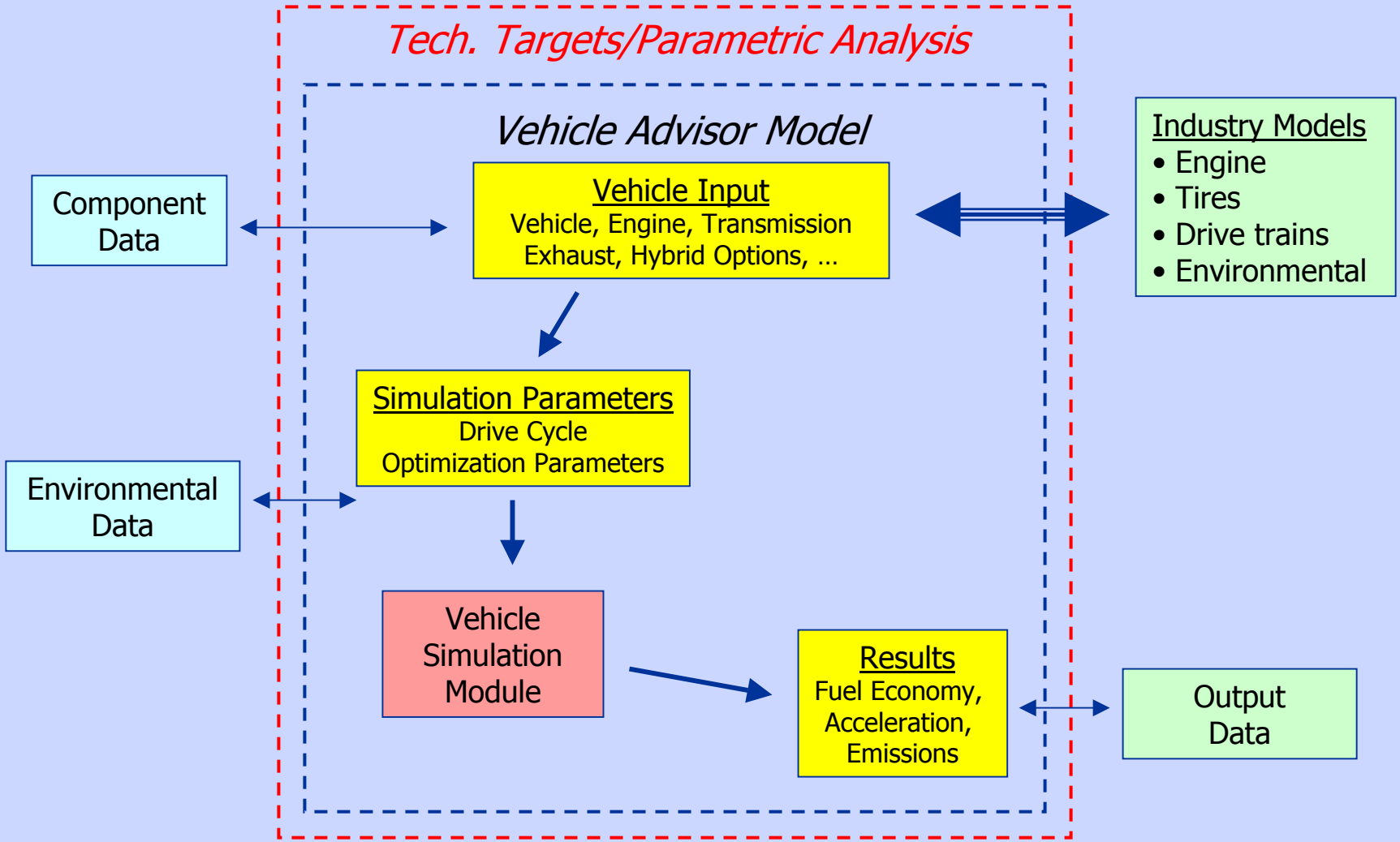


Legend

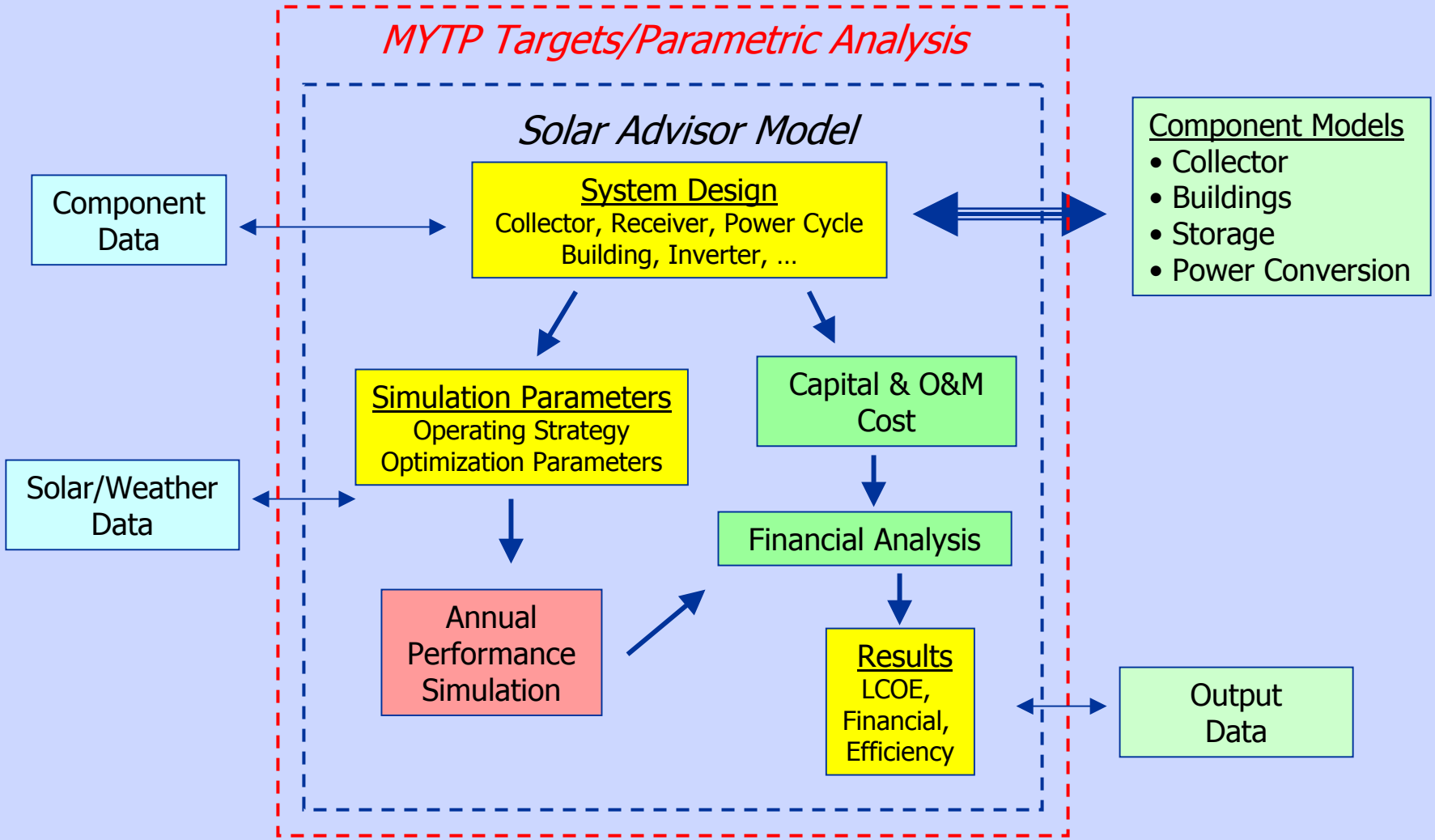
Milestones

1.Develop standard technology configurations
2.Develop technology benchmark input requirements
3.Develop standard financial/economic assumptions for baseline configurations
4.Identify existing program/technology analysis capabilities
5.Identify existing or recommend development of new market-based systems analysis platforms
6.Select candidate market(s) for near-term development of integrated analysis platforms
7.Demonstrate beta version of 1-2 integrated solar analysis platforms for selected markets
8.Demonstrate beta versions of integrated solar analysis platforms for remaining market sectors
9.Demonstrate integrated analysis platform for integrated market sectors
10.Identify out-year technology cost projections based on existing program/technology documents (roadmaps, program plans, etc…)
11.Conduct rigorous due-diligence like review of out-year projections (not including troughs/towers)
12.Align program/technology goals with EERE and National goals and interests (i.e. conservation, infrastructure, energy supply, environment, security)
13.Complete initial analysis estimating long-term benefits that are aligned with National goals and interests
14.Complete trade-off studies identifying highest impact technologies for each market sector
15.Identify high-level market-specific technical/economic measures of success for each technology (i.e. LCOE, payback, first cost)
16.Complete development of initial system level technical/economic targets for each high-level MOS
1Document cost, performance, and reliability FY03 benchmarks for each OSET technology based on standardized assumptions
1Define parameters of program-wide cost, performance, and reliability data collection requirements

Vehicle Advisor Model



Solar Advisor Model



Model Development Tasks

- Develop Software Requirements Specification
- Develop Graphical User Interface
- Develop performance models for standard PV, CSP, and SH configurations
- Develop financial assumptions and models for standard configurations
- Integrate GUI, performance models, and financial models into first beta-model

PV Systems Analysis Model

Roland Hulstrom, David Mooney, and Bill Marion

Solar Energy Technologies Systems Symposium

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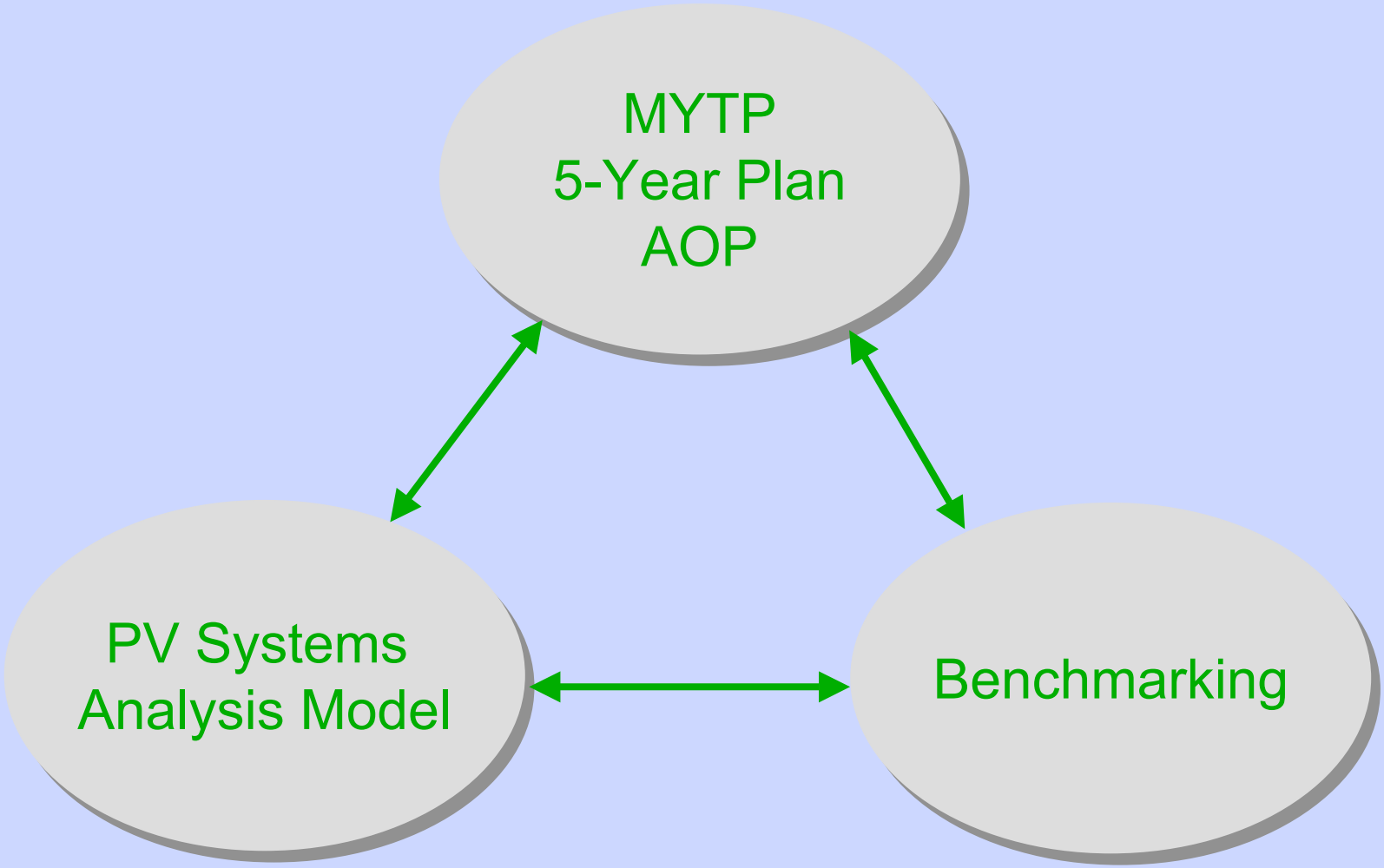
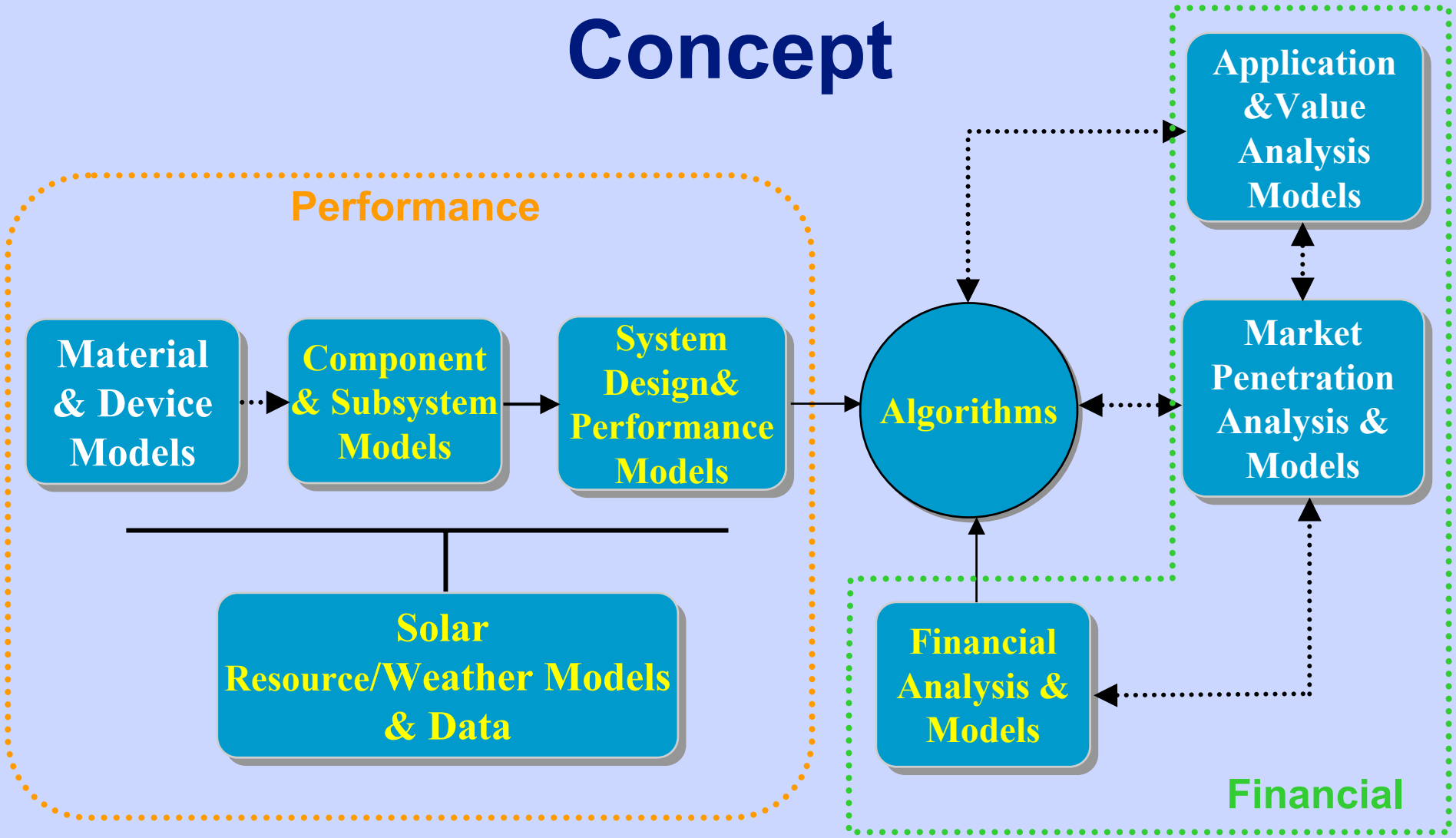
Model Considerations

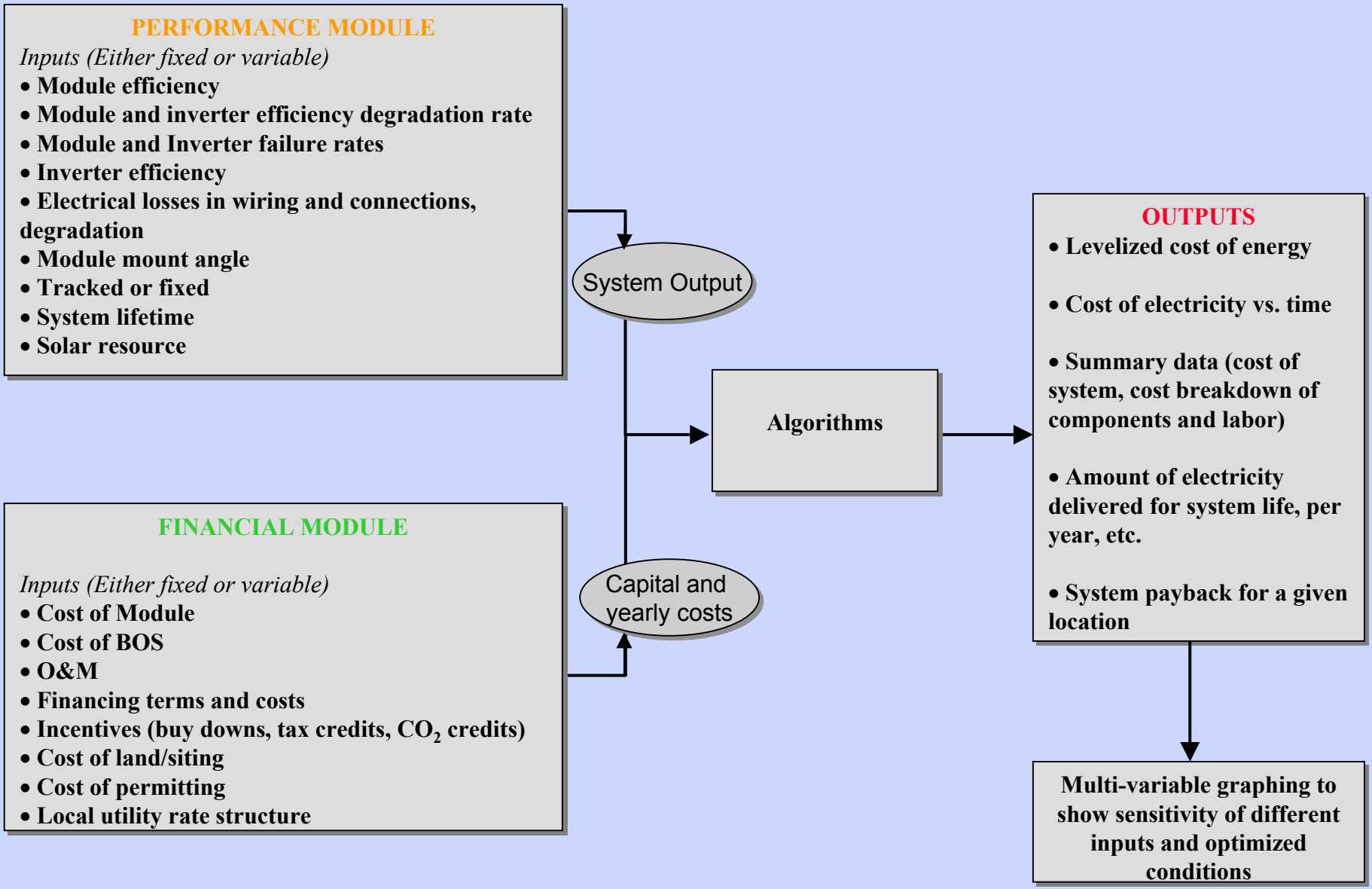
- Component-level sensitivity analysis *from system perspective*
- Utilize analysis to inform R&D investment decisions
- Comprehensive model to accurately predict system performance
- Benchmarking effort critical to model credibility

Programmatic Context



Concept


Performance
Material & Device Models
Component & Subsystem Models
System Design& Performance Models
Solar Resource/Weather Models & Data
Algorithms
Application &Value Analysis Models
Market Penetration Analysis & Models
Financial Analysis & Models
Financial


PERFORMANCE MODULE
Inputs (Either fixed or variable)
• Module efficiency
• Module and inverter efficiency degradation rate
• Module and Inverter failure rates
• Inverter efficiency
• Electrical losses in wiring and connections, degradation
• Module mount angle
• Tracked or fixed
• System lifetime
• Solar resource
System Output
FINANCIAL MODULE
Inputs (Either fixed or variable)
• Cost of Module
• Cost of BOS
• O&M
• Financing terms and costs
• Incentives (buy downs, tax credits, CO_2 credits)
• Cost of land/siting
• Cost of permitting
• Local utility rate structure
Capital and yearly costs
Algorithms
OUTPUTS
• Levelized cost of energy
• Cost of electricity vs. time
• Summary data (cost of system, cost breakdown of components and labor)
• Amount of electricity delivered for system life, per year, etc.
• System payback for a given location
Multi-variable graphing to show sensitivity of different inputs and optimized conditions

PV Systems Analysis Model

- **Select/Modify a Default System**
- **Build your Own System**

Select System Type

Utility Scale

BIPV

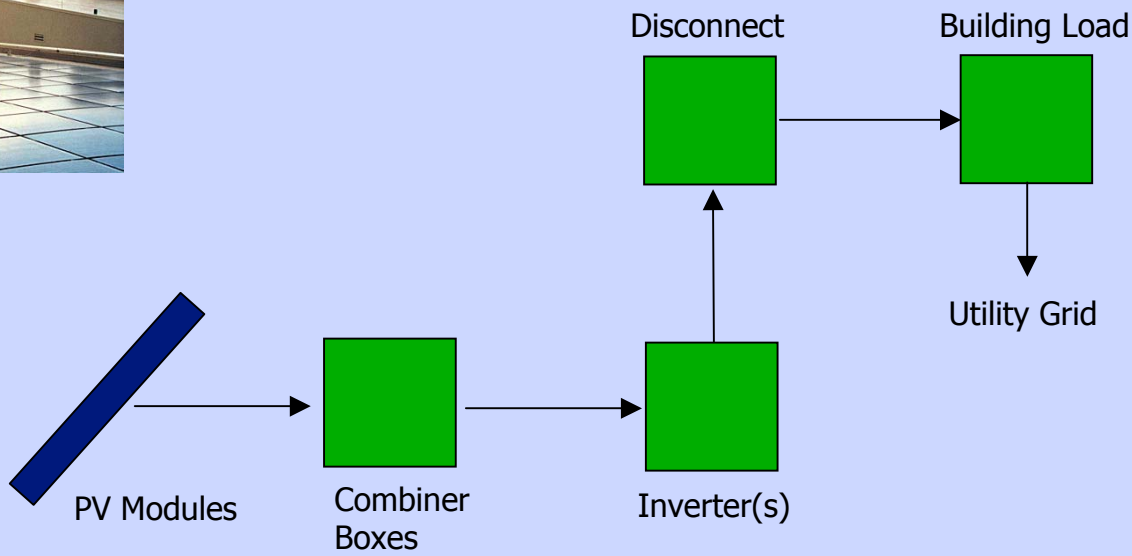
Commercial

Small-scale
Stand Alone

Residential Grid-tied

Large Load
Stand Alone

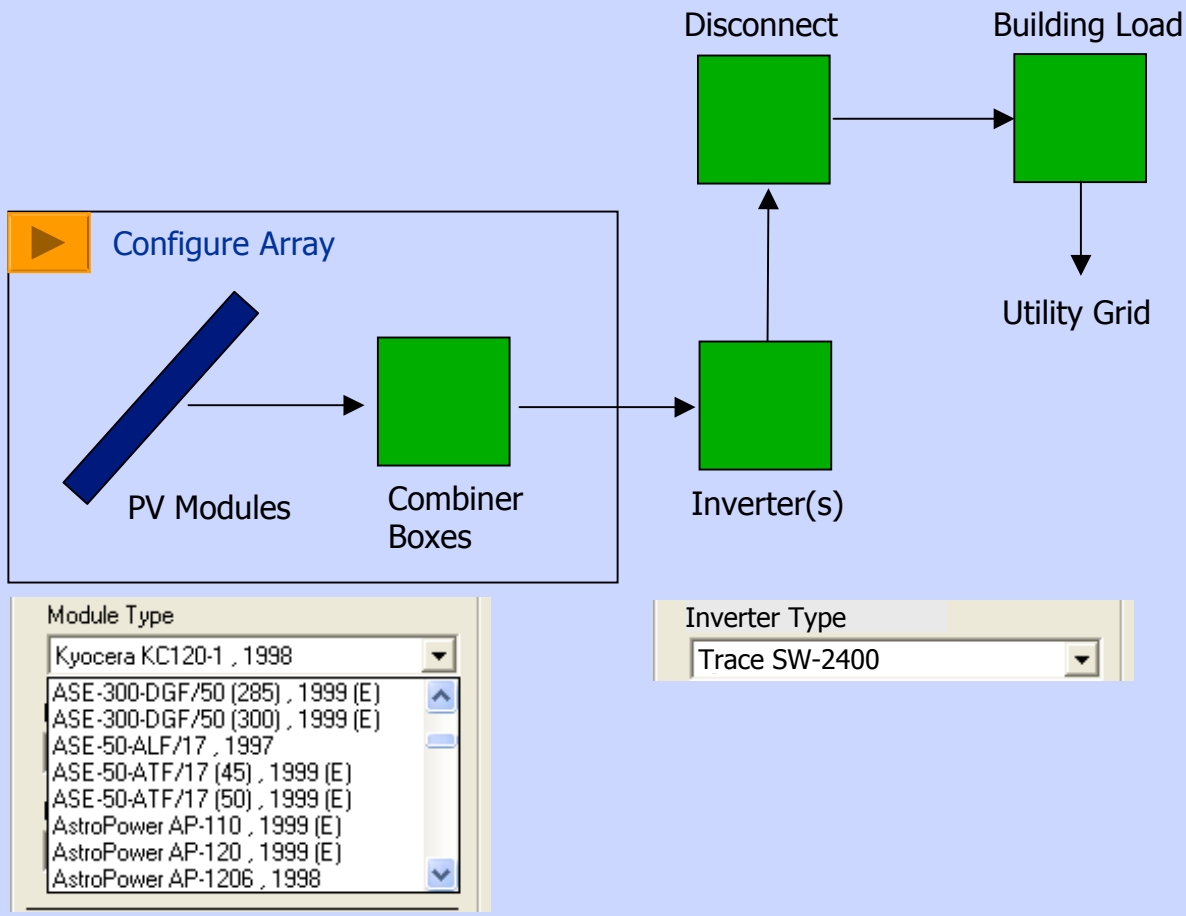
Commercial Scale System



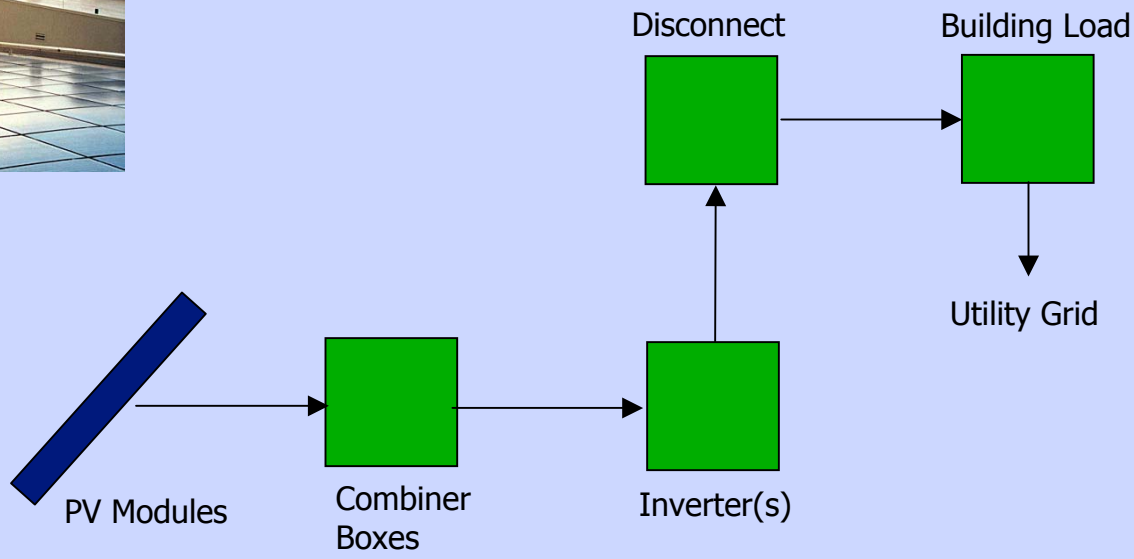
Calculate System Performance and Cost

- Work with Default System
  - View Systems Specs
- Modify System Specs

Commercial Scale System



Commercial Scale System



PV Module Performance Parameters

PV Module Financial Parameters

Module Specs

Module Performance				Module Size	
Fixed Module Efficiency	13%	Fixed Module Efficiency		Total Area (m^2)	0.87
Module Efficiency Degradation Rate (relative %/yr)			0.50%	Active Area (m^2)	0.64
Module Failure Rate (average # per year)		0.5			
Soiling Losses	2%				

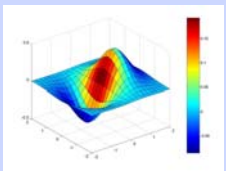
PV Cell Performance Parameters

Go back to systems schematic

PV Module Financial Parameters

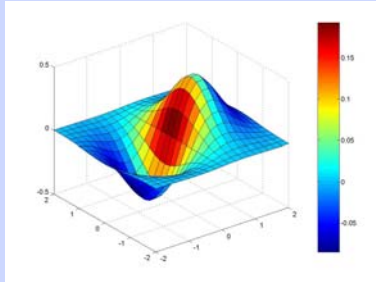
Outputs

	Energy Cost per Year														
	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15
Levelized Cost per Year	$ 0.43	$ 0.43	$ 0.42	$ 0.42	$ 0.41	$ 0.41	$ 0.40	$ 0.40	$ 0.39	$ 0.39	$ 1.01	$ 0.38	$ 0.37	$ 0.37	$ 0.36
Energy Output (kWhr)	29,567	29,272	28,980	28,691	28,405	28,121	27,841	27,563	27,288	27,016	26,746	26,480	26,215	25,954	25,695
Payments+O&M	$12,757	$12,469	$12,189	$11,916	$11,650	$11,392	$11,140	$10,894	$10,656	$10,423	$26,997	$9,976	$9,762	$9,553	$9,350
AVERAGE ANNUAL COST OVER LIFETIME			$11,251												
AVERAGE ANNUAL ENERGY OUTPUT			26,926												
LEVELIZED COST OF ELECTRICITY			$ 0.42												



Go to Graphing Module

Graphing Module



Select Items You Wish to Plot

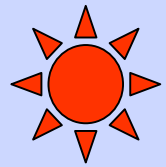
Performance Parameters

- [x] Annual AC Output
- [ ] Annual DC Output
- [ ] Monthly Output
- [ ] Array Max Power
- [ ] Module Output
- [ ] Inverter Efficiency
- [ ] Irradiance

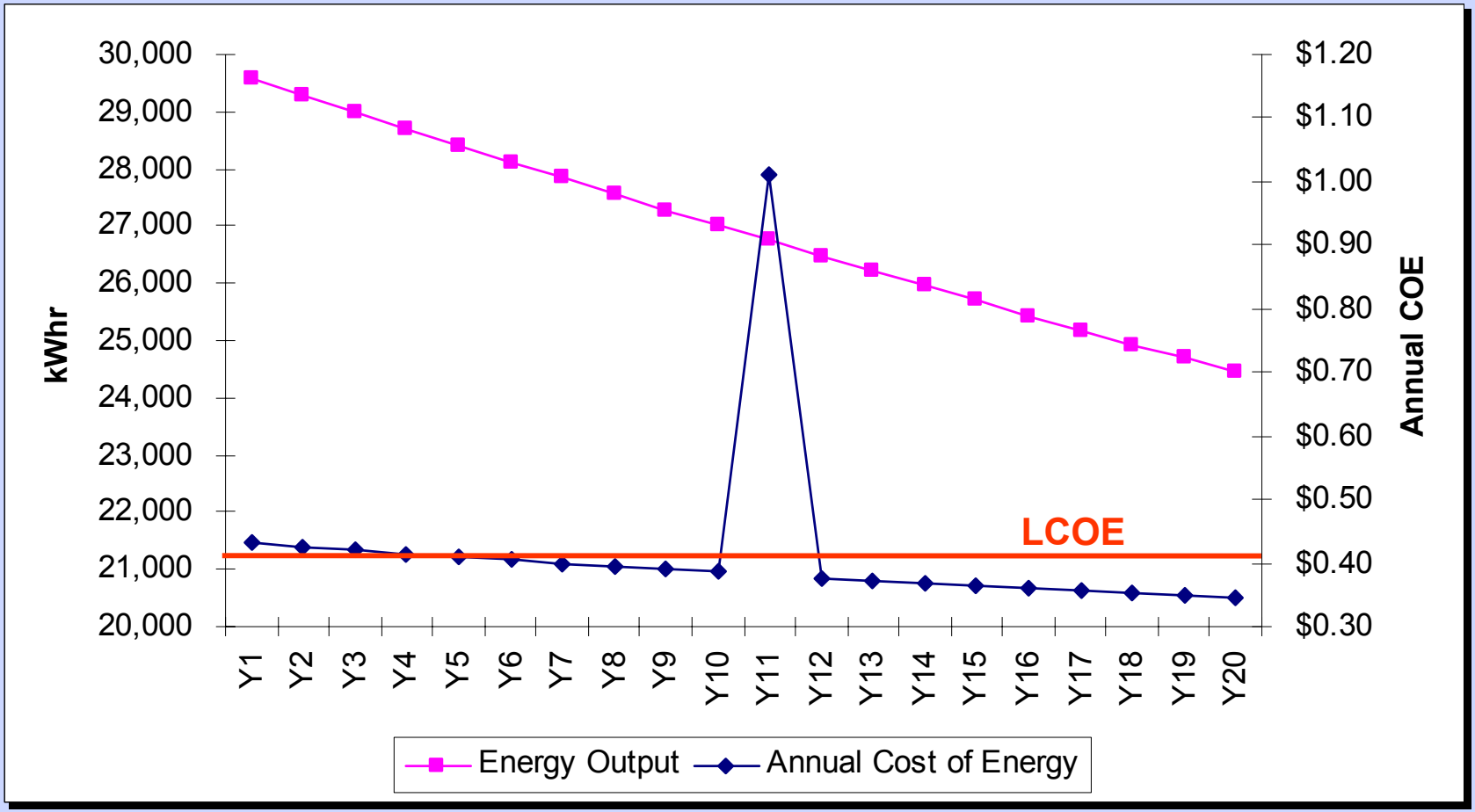
Financial Parameters

- [ ] Annual Costs
- [ ] Energy Value
- [ ] LCOE
- [ ] System Cost Breakdown
- [ ] Module Cost Breakdown
- [ ] BOS Cost Breakdown
- [ ] System Payback

- [ ] CUSTOM GRAPH



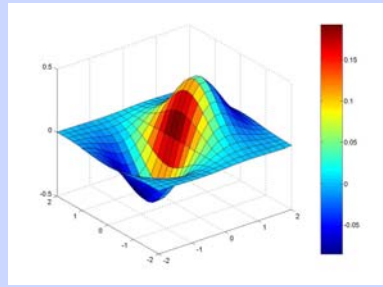
Generate Graph



Back to Graphing Module

Save Graph

Graphing Module



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Financial Parameters

- ☐ Annual Costs
- ☐ Energy Value
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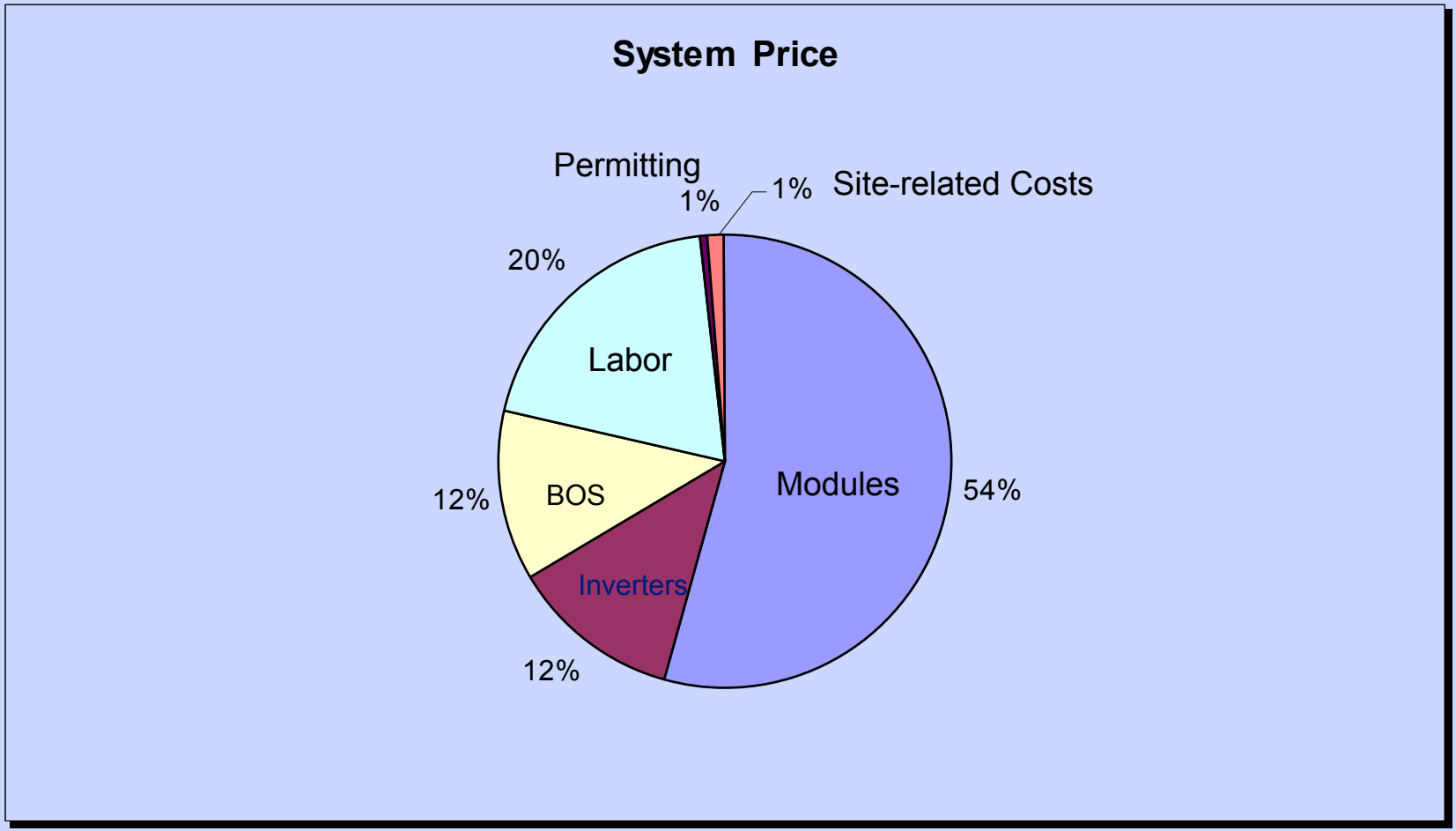
- ☐ BOS Cost Breakdown
- ☐ System Payback

☐ **CUSTOM GRAPH**

Generate Graph



Back to Graphing Module
Save Graph

Next Steps for PVSAM

- Convert Excel code to MatLab Code
- Continue visits with industry and others
- Compile/incorporate databases
- Evaluate/incorporate existing accessible models

Acknowledgements

- Roland Hulstrom
- Mark Mehos
- Craig Christensen
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